Future Technologies:
Clean and Quiet

Federal Aviation Administration
Air Transportation Centers of Excellence
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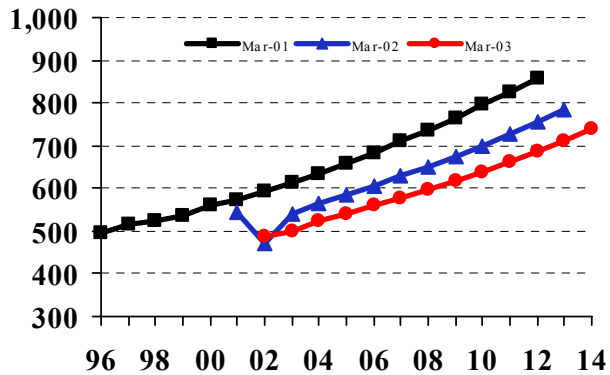
Future Aviation Drivers

- Americans want safe, convenient, inexpensive air travel
- Americans want the environment protected
- Environmental issues remain a long-term capacity constraint on aviation
- Solutions a function of innovation and R&D investment

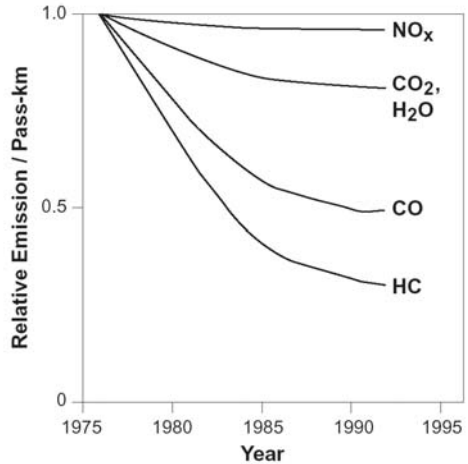
Abating Environmental Impact Challenges

GROWTH



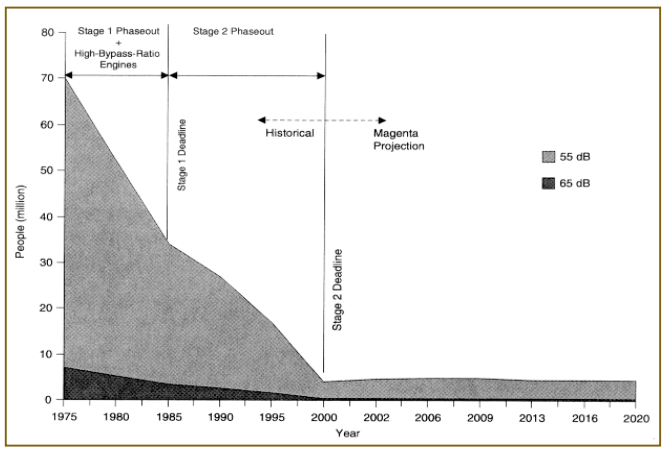
FAA Aerospace Forecasts, 2003

HISTORICAL TECHNOLOGY TRENDS



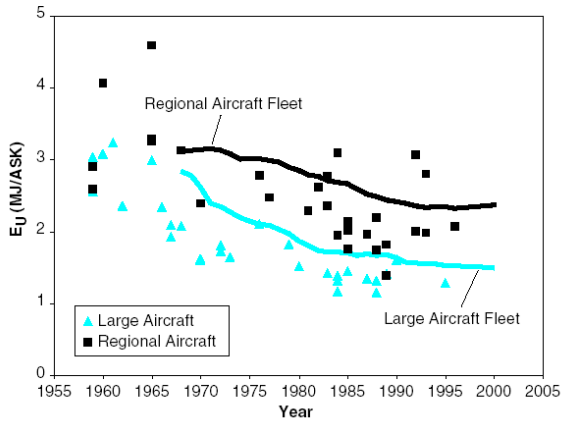
Source: Waitz, 2002, based on Boeing data

INCREASED STRINGENCY AND EXPECTATIONS



Source: Lukachko and Waitz, 2001

CHANGING FLEET MIX



Babikian et al., 2002

Future Technologies: Quiet Aircraft Technology

A NASA-FAA Partnership

Vision

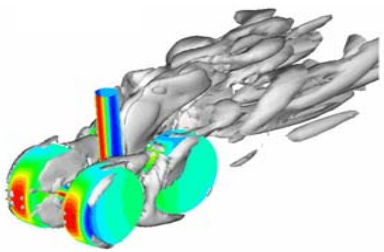
- Objectionable aircraft noise contained within airport boundary

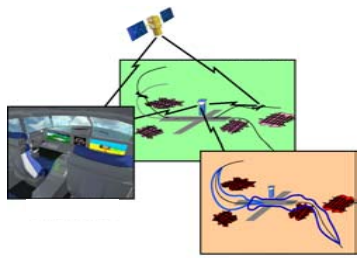
Enterprise Noise Goal

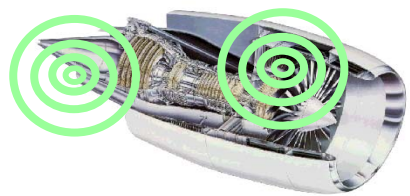
- Reduce the perceived noise levels of future aircraft by one half (10 dB) from today's $_{1997}$ subsonic aircraft within 10 years, and by three quarters (20 dB) within 25 years

Benefit

- 10-year Goal: Technology for 65 LDN at airport boundary
- 25-year Goal: Technology for 55 LDN at airport boundary







Future Technologies: Ultra Efficient Engine Technology

Vision

- Minimize impact of air vehicles on local air quality and climate change

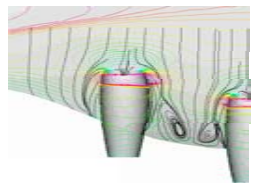
Enterprise Emissions Goal

- 70% Landing/Takeoff (LTO) NOx reductions relative to 1996 International Civil Aviation Organization (ICAO) Standards
- Fuel burn reductions of up to 15 % (equivalent reductions in CO2)

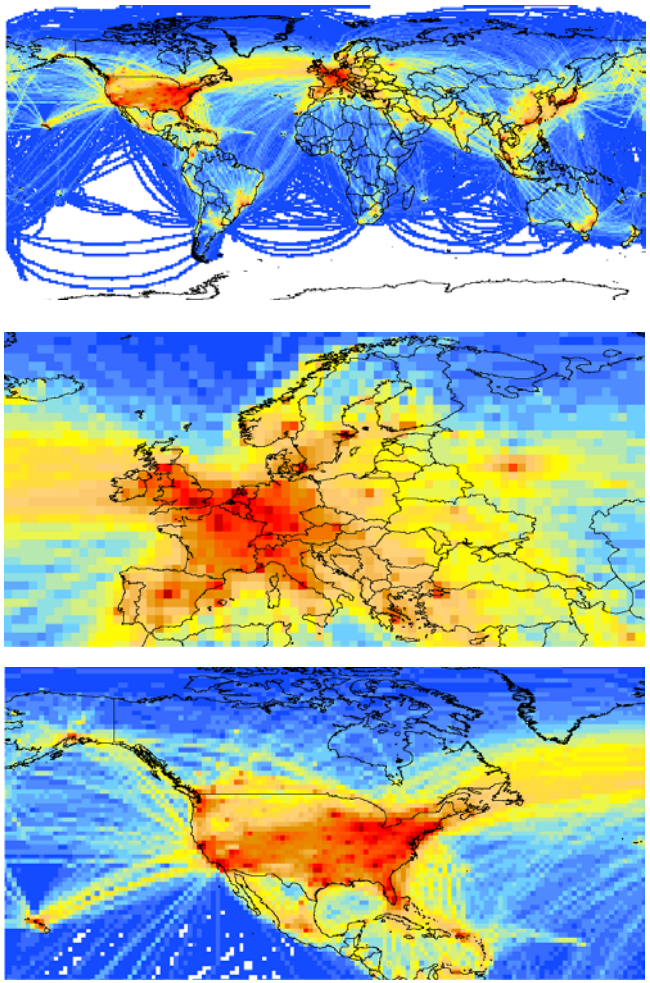
Benefit

- Reduces emissions from aircraft during LTO and cruise segments -- benefits airport neighbors, travelers, global climate, and the aviation industry



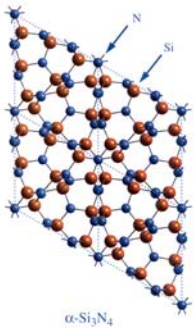
Near-Term Opportunity:
Inform Decision-making

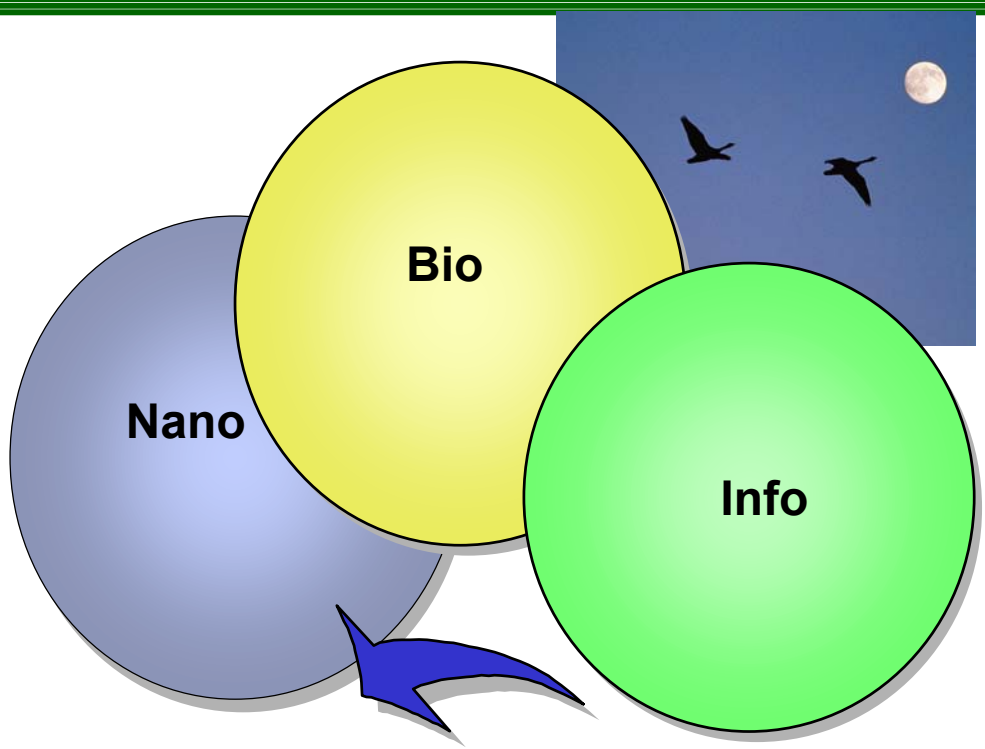


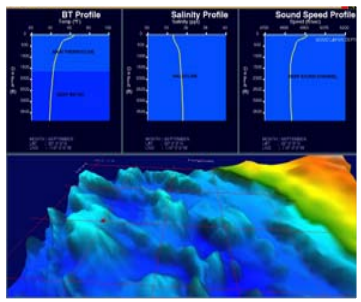
Plots of global, European and U.S. carbon dioxide emissions for 2000

System for assessing Aviation Global Emissions (SAGE) computer model has the unparalleled capability to vary base year inputs and operational, policy, and technology-related scenarios to estimate aircraft emissions from a single flight to a global scale

Long Term – Create a Technological "New Normal"







Fuel Cell Evolution for Aircraft Applications

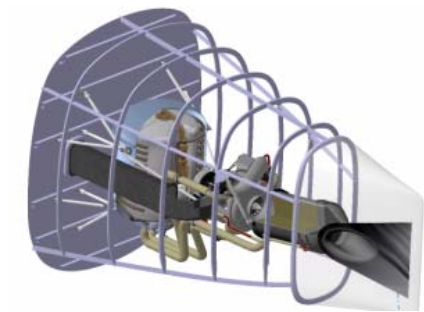
Industrial Solid Oxide Fuel Cell Installations

2003

- 47% efficiency
- > $10,000/kW
- Two years operation
- No weight or size consideration
- Natural gas fired

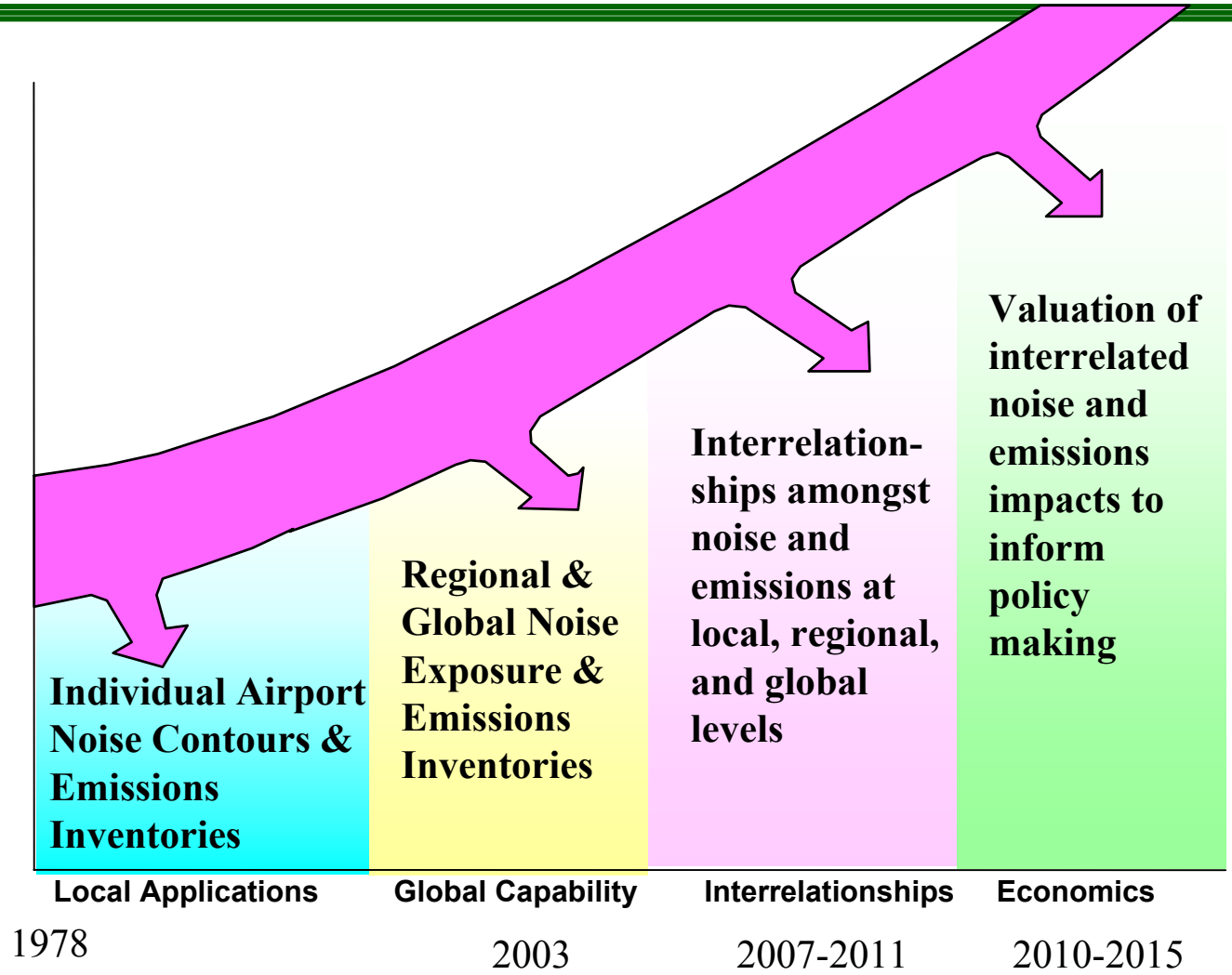
2015 *(desired characteristics)*

- 60-75% efficient in flight
- < $1,000/kW
- 40,000 hr life
- Light weight (0.5 kW/kg)
- Uses Jet-A fuel



Concept 440 kW Solid Oxide Fuel Cell in Commercial Airplane APU Tail Cone

Long-Term: Integrated Noise & Emissions Analyses Tools



Summary

We must address noise and emissions public concerns -- predicated on solid understanding of impacts -- as part of any future National Air Transportation System vision and technology development investment strategy